Contactless Viscosity Measurement by Gas Film Levitation

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A recently demonstrated aerodynamic levitation technique is used to perform contactless viscosity measurements. A pressurized gas is forced through a porous membrane creating a gas film on which a liquid droplet levitates. The dynamic response of the droplet is presented. Classical model dealing with free oscillations and damping of droplets without gravity cannot correctly describe the correspondence between both damping coefficient and viscosity. An energetic approach taking into account the flattened shape of the drop, the particular boundary conditions imposed by the set-up, and the velocity field of the liquid inside the drop, is introduced, leading to good agreement between experimental measurements and known viscosities of glycerol/water mixtures and calibrated silicon oil. Experiments on suspensions of silicate spheres in silicon oil demonstrate the ability of the set-up to measure the viscosity of complex fluids (two phases). The set-up has been used to perform contactless viscosity measurement on metallic alloys in the semi-solid state (Cu-Ag, 1100 K), showing that even at relatively low solid fraction (30%) aggregation increases the viscosity by 6 orders of magnitude. Viscosity measurements on silicate glasses at very high temperature (2800~K) have also been performed, revealing of the presence of a crystalline phase in the melt.